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ABSTRACT

When students feel that their learning needs are not being met by computer-aided instruction, learning becomes passive, often resulting in boredom, frustration or a dislike for learning with computers. "Button Theory" allows the student to express his feelings and questions to the computer at the touch of a button, thus enhancing control over the learning process. "Button Theory" is implemented by means of a comprehensive set of messages, which the student can use to interact with and control the computer-based tutor; each message corresponds to one button represented by an icon on the computer screen. In order to examine the feasibility and adaptability of "Button Theory" across different computer-based learning environments, it was implemented in a prototype CAI system on astronomy, Solaria. Thirteen buttons were chosen for implementation in Solaria, and were divided into three categories: feelings, questions, and control. Messages in the questions and control categories were found to be generic, while those in the feelings categories were less so. One implication of this is that the development of a learning environment based on "Button Theory" would be simplified; a core set of conditions or contextual variables on which to select a response to a button press is needed. (AEF)

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Study of Button Theory in Structuring Human-Computer Interaction in a Multimedia System

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Abstract: Much research has been directed towards the interactivity of computer-aided instruction (CAI) software. *Button Theory* allows the student to express his feelings and questions to interact with the computer at the touch of a button, thus enhancing control over his learning process in a CAI environment. We describe the initial results of our study in implementing *Button Theory* in a directive learning environment and offer some comments on its genericity in different learning environments from a designer's perspective.

Introduction

In most computer-aided instruction (CAI) software as well as other computer-based learning environments today, students generally lack control over the instruction they receive. When students feel that their learning needs are not being met, learning becomes passive for them, often resulting in boredom, frustration or a dislike for learning through computers.

Button Theory advocated by Roger Schank's group at the Institute for the Learning Sciences [Jona et al, 1991], provides the student using computer-based learning environments with as much control over what they see, hear and learn. *Button Theory* is implemented by means of a comprehensive set of messages, which the student can use to interact with and control the computer-based tutor. Rather than using natural language processing (which is difficult), each message corresponds to one button, represented iconically on the computer screen.

This paper reports on a project to explore the feasibility of incorporating *Button Theory* in a hypermedia CAI system. We seek to address this question: how feasible and adaptable is the use of *Button Theory* across different computer-based learning environments. We are currently approaching this from a designer's perspective and have not gone on to doing this from the user's perspective. We have implemented our interpretation of *Button Theory* in a prototype CAI system on astronomy called *Solaria*. Following a detailed description of the interpretation and implementation of *Button Theory* in *Solaria*, we will discuss the genericity of the theory, i.e. we will discuss whether each message (and hence, the button) proposed in the theory can be general enough to be used in different domains. The *Solaria* prototype is programmed in HyperTalk 2.0, the scripting language for the Macintosh HyperCard 2.0.

Button Theory proposes three categories of possible discourse between the student and the system. The three categories and the messages in each category are:
Feelings - "Awesome!", "Boring", "No Way", "Huh?", "Too Hard";
Questions - "How Do I Do That?", "Now What?", "What's the Point?", "Why?", "History";
Control - "Change Task", "Back up", "Big Picture", "More Detail", "Skip This."
A full description of the meaning of each can be found in the original paper [Jona et al, 1991]. We will next discuss our interpretation of the *Button Theory* in *Solaria*.

Interpretation of the Button Theory

Out of the 15 buttons proposed by *Button Theory*, 13 buttons which were most appropriate to the context of the domain i.e. astronomy were chosen for implementation in *Solaria*. The main function of these buttons was

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to act as user responses and control to interact with *Solaria*.

Implementing them, however, was tedious as each of these buttons could be interpreted in many ways. This was due to their flexibility and relative generality. To reduce overlapping interpretations between buttons and to maintain consistency in system response, the interpretations for each button were pared down to only the essential ones. We expect that this streamlining will in no way reduce the responsiveness of *Solaria* nor the interaction between the user and *Solaria*. In fact, having an essential set of interpretations helps to train the user to more accurately express his feelings by selecting the most appropriate buttons. This will help to prevent abuse of or over-reliance on general buttons like "Huh?" and "Why?".

Feelings Group

Awesome The user expresses his enthusiasm for the current topic or task being learned. This button serves basically as feedback to the teacher from the student as regards to the subject/topic under study at that particular point in time. This button which conveys the user's enjoyment provides an important opportunity for the teacher to gather useful information about the student's preferences and interests.

Too Hard The user is suggesting that the material presented is too hard for comprehension. As such, he will like to be given the option to restart the same topic again at a lower level of complexity. At that level, the difficulty level of the material will be less and the style of presentation will also be simplified.

Boring The user is suggesting that the material presented is too easy and that he is getting uninterested. As such, he will like to be given the option to restart the same topic again at a higher level of complexity or presented with more interesting material on the current topic. At that level, the scope of the material will be wider and the topic will be studied in greater detail.

Huh? "Huh?" is a very general button that can be easily abused. Therefore, the interpretations were limited to these few essential ones which are, as far as possible, not duplicative of other button interpretations. In fact, special care has been taken to ensure that its interpretations do not clash with those of the other general buttons, such as "Why?" and "What's the Point?"

i) Under normal circumstances, the user is indicating a complete lack of understanding to the material being presented and would like a further or alternative explanation.

ii) If this button is selected after some animation or display, it is similar to i) and the user is seeking further clarification on the animation or display. It should be noted that for some of the queries the user is asking, the more appropriate button to select should be the "Why?" button. The "Huh?" button acts as a catch-all safety net which will handle the rest of the queries which are not covered by "Why?".

iii) If this button is selected right after some recommendation has been made to perform some action, the user is indicating that he does not know how to go about performing the recommended action. For example, Solaria can suggest to the user to click on an icon of the Halley's Comet to see an animation. At this point, if the user clicks on "Huh?", it indicates that he does not know that he is supposed to move the cursor and select the comet icon by shifting the mouse and clicking on the button.

Questions Group

History The user needs to know all the topics that he has covered so far. He is presented with a sequential list of these topics covered.

How (do I do that)? After viewing certain animation or experiment being conducted, the user will like to given a step-by-step demonstration on how to duplicate the experiment.

Now What? The user is expressing that he is unsure on where to proceed to or what to try out next and will like to be provided with some recommendations.

What's the Point? Depending on the circumstances, there are two separate system responses provided. Even though the responses are different, selecting this button can still essentially be viewed as asking the question: What is the point of that?

i) If selected right after a recommendation was made for the user to perform or try something, it is indicative that the user wants to know how this suggested action relates to the topic being taught.

ii) If selected after some animation or display, it is indicative that he needs to know how the presented relates

to the topic being taught. Basically, the question being asked is: What is the point of having me do that? For instance, under the topic of gravitation, an animation was shown of the planets moving around the sun. By clicking on "What's the Point?", the user is asking: "What is the point of having this animation shown within the topic of gravitation?" The system response would be: "To illustrate the forces of gravitation at work in our solar system."

Why? This is one of the more general buttons and can have one of these interpretations:

i) Under normal circumstances, the user is implying that he does not understand or that he does not agree to the logic of the material being presented and would like further clarification.

ii) If this button is selected right after some animation or display was presented, it is similar to (i) and the user is seeking further clarification on the animation or display. For instance, under the same example given under "What's the Point?", an animation of the planets moving around the sun was shown. By clicking on "Why?", the user might be asking: "Why do the planets move in uniform ellipses around the sun?" The system response would be: "This is due to the gravitational forces between the sun and the planets."

iii) If this button is selected right after some recommendation has been made to perform some action, the user is looking for a relation between the suggested action and the topic under study. He is basically asking the question: "Why should I do that?" This is in fact similar to "What's the Point?" under the same conditions.

Control Group

BackUp The user feels a need to review the previous material covered before continuing.

Skip The user is finding the current topic uninteresting, difficult or boring, and wishes to proceed to the next topic. It must be noted that this button does not duplicate the functions of the "Boring" and "Too Hard" buttons. Those buttons returns the user back to the beginning of the current topic at a different level of difficulty.

More Detail This button indicates the student's desire for more information on the current topic.

Big Picture The user feels that he needs to know how the current topic relates to the parent topic or even astronomy.

Genericity of the Button Theory

We will discuss whether each message (and hence, the button) proposed in the theory can be general enough to be used in other domains. By generic, we mean that the code associated with the message or button is operative or easily adaptable in any environment without any major modifications. i.e., it is possible to develop a "template" of codes which can be implemented in any domain. In HyperCard™ terms, there are basically two containers: CONTEXT and RESPONSE. CONTEXT contains the list of conditions in the form of predicates whereas RESPONSE contains a list of statements on how the system should respond when the conditions evaluate to true. The code for generic buttons is composed of pseudo-code statements such as:

If CONTEXT then RESPONSE

The conditions employed by *Button Theory* have been classified into the three main groups of student goals, student knowledge, and communication history, and are expressed as predicates [Jona et al, 1991]. To formulate appropriate or meaningful responses to the messages expressed by the system, the developer of the system needs to analyse all the possible conditions, and then determine suitable combination of conditions which describes all possible contexts in the system. Next, he needs to design suitable responses for each context.

We illustrate by examining the response to "Why?" Let's consider the possible context for "Why?" For example, a student may be presented with a fact (e.g., "the earth revolves around the sun", or "animals fight over territory and food") or asked to do some task (e.g., "drag the pendulum away from the centre") or he may have observed some actions (e.g., a chimp walking up to another chimp and threatening it). The student then asks why with regards to any of the scenario above. When a fact is presented, the condition "Fact-Presented" would be true. When user is asked to do a task, the condition "Action-Asked" is set to true. Similarly for the last scenario. Hence, to determine the context, each relevant condition in the set of conditions is tested. Once the context is determined, appropriate responses can be made.

Types of Learning Environments

As there are many different types of environments of teaching and learning, it would be appropriate to categorise all environments. We look initially at two broad types of learning environments. The first one is directive teaching/learning in which the environments cover instructional or factual materials. An example of an instructional environment would be "How to operate a sophisticated machine" where teaching involves providing the learner with a set of step-by-step instructions to operate the machine. An example of a factual environment generally would be academic in nature such as physics or chemistry or as implemented, astronomy. In this environment type, the facts are presented and taught to the student.

The second category is one of exploratory or discovery teaching/learning. An example would be the *ChimpWorld* environment described in [Jona et al, 1991] to teach the behaviour of chimpanzees. The messages/ responses from the student will differ from the first category. [Chay et al, 1994] provides a comparative analysis of the buttons used in *Solaria* and *ChimpWorld*.

We will next discuss the genericity of the theory in relation to these two types of learning environments.

(a) Some buttons proposed in the theory but are not necessary or relevant

In the implementation of the theory in *Solaria* (one of directive teaching and learning type of environment), 13 of the 15 messages were used. The two messages in the initial theory not used are "No Way" and "Change Ttask". "No Way" was excluded for the simple reason that it is used to express the student's disbelief or surprise of some thing, probably fact, presented. To respond to this expression will be very difficult as the cause of the feelings would be unknown to the system. Hence, we would rather the student express this feeling in another form, probably by asking questions "Why?", etc.

On the other hand, "Change Task" was excluded as we felt that the message was more appropriate for the intuitive or exploratory type of learning where a student can choose to change the task that he is currently doing. In the case for astronomy, the student can easily change the topic of teaching by going back to the menu to select another topic. Thus, messages that deal specifically with intuitive or discovery learning may not be relevant in an environment which is directive or factual in nature.

(b) Some buttons not proposed in the theory but are necessary

There were also some messages which were needed but not proposed. The messages in this category are mainly those of the fact-seeking or fact-clarification type. An example would be when a student is learning about solar eclipses, he would like to know about other types of eclipses (if any) in which case he would need to express the "What are the related topics" message. We tried to circumvent such messages using those that were proposed. Although certain messages can be circumvented or rephrased easily, there were some messages that were quite ambiguous as a result of circumvention. There are yet others that just could not be rephrased in any other way. In the latter case, we propose new messages and hence buttons.

An example of a message that is not supported by the theory is "What makes the Sun appear brighter than the other stars?" or "How is it that the Sun appears very bright?". Both these messages can be circumvented using "Why does the Sun appear brighter than the other stars?". This is an easy example. Others may not be easy.

Two new buttons were used in the system. They were "Glossary" and "Related Topics". Both these buttons are related to fact-seeking as mentioned earlier. "Glossary" provides a simple explanation of a term while "Related Topics" provides curious students with more facts.

One very prominent question or message that is not in *Button Theory* is "What?" It seems that in a directive environment, a significant number of questions can be based on "What?". We also suggest that the "How do I do that?" message be expanded to just "How?". This is to include other "How?" questions such as "How does the earth revolve around the Sun?" or "How is our Sun like other stars?" We however did not experiment further with this suggestion although the need for such a message did arise a few times.

(c) Environment specific buttons

To summarise, there are buttons which are mainly used in a directive environment for learning, and there are others that seem only relevant to an exploratory or intuitive environment. Examples of the former are "Related topics", "Glossary", etc. while examples of the latter environment would be "No Way" and "Change Task". Some other buttons in the theory, which have the same semantic sense in both the types of environments, could very well be different functionally. The "Too Hard" message in a directive environment would mean that the student finds the material too difficult to understand and an appropriate response by the system would be to

rephrase the concept/fact in simpler terms. However, in a exploratory environment, "Too Hard" could be used to express the same feeling but the system would respond either by reviewing the material in a slower manner or by asking the student to carry out some active task which would increase his understanding.

Another environment specific button that needs to be mentioned is the "Huh?" button. This button is used as a catch-all, with the student using it to the exclusion of the other buttons. As a result, it is so general and very vague and therefore, by that inherent characteristic, is very environment specific. In fact, this button is not just environment (directive or exploratory) specific but is even domain-knowledge specific. For example, an appropriate response to "Huh?" in physics might be very much different from that in botany, even though in both domains, it conveys the student's confusion.

Other buttons that might be environment specific (and may be to a certain extent domain of knowledge as well) are "Awesome!" and "Boring". As both these buttons are used to express some feelings, it is up to the designer or developer to interpret those feelings and to respond to them in the most appropriate way deemed by him/her. For example, we decided at some times to interpret "Boring" to mean that the material was too easy while at other times, the material was too dry. The response to the former was to present further materials with a higher level of difficulty while the response to the latter was to either tell a story, myth or legend relating to the material presented or simply ask the user to skip the topic or skip to a harder level (see diagrams in next page). In summary, it seems that all the buttons under the "Feelings" category of messages are environment specific buttons. This is quite logical considering the nature of the category.

(d) Environment independent buttons

Basically, the buttons not in the previous category belong to this category. This would mean that all the buttons in the "Questions" category and all but one button (i.e., "Change Task") in the "Control" category are environment independent. This may not be surprising for buttons in the "Control" category.

However, for buttons in the "Questions" category, one would expect that since the messages in the category pertain to the domain, this would inherently imply that such buttons are also environment specific. However, we concluded otherwise. The main reason for this is that in order to make appropriate or meaningful responses to the messages expressed by the student, the system needs only consider the contexts that the student is in when such messages are expressed. Indeed, the contextual elements proposed in *Button Theory* (e.g. Current-Goal-Explained or Current-Goal-Not-Explained, Action-Not-Explained, Repeated-Last-Button-Press) contain no predicates that relate directly to the domain [Jona et al, 1991]. In any given environment or domain, the context can be derived from such a set of determinable conditions. All possible conditions must be thoroughly analysed by the developer. Appropriate responses to messages can then be made by examining the relevant conditions.

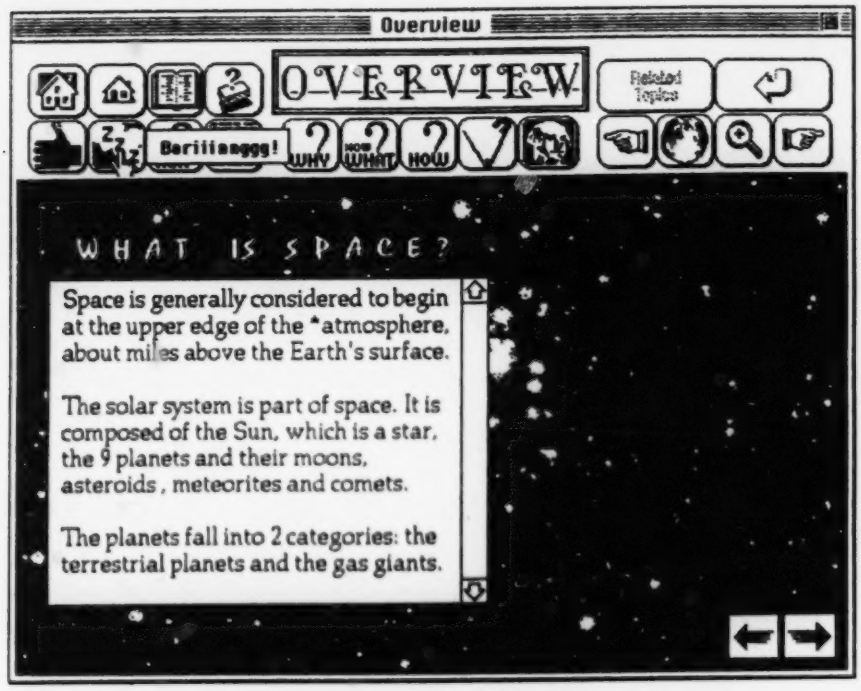
Conclusion

In summary, this study suggests that the buttons/messages in the Control and Questions categories can be generic while those in the Feelings category are less generic. One implication of this is that the development of a learning environment based on *Button Theory* would be simplified. We need to acquire a core set of conditions or contextual variables on which to select a response to a button press [Jona et al, 1991]. Templates of codes for the responses need only to be developed once. For a different domain, these codes can be copied and incorporated into the system. The developers of the system need only provide additional contextual variables, if needed, and the rules by which the buttons (and the system) respond to the user. A definite area for further work will be to conduct studies of actual students using the system. This will provide further empirical studies on *Button Theory*. Another area to investigate is the extent to which *Button Theory* ease or increase the cognitive load on the students that is created by "navigating" while trying to learn, compared with other types of user-interfaces.

References

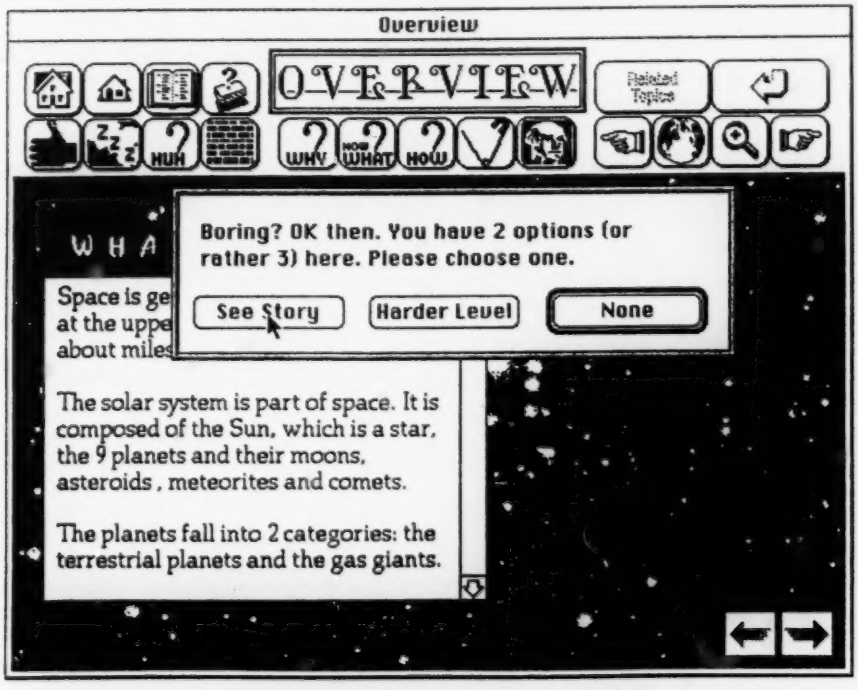
Chay, J.K., K. Chan & L. Chew (1994). A Study of the Genericity of *Button Theory* in Different Learning Environments, internal report, Department of Information Systems & Computer Science, NUS, Jan 1994.

Jona, Menachem, B. Bell & Birnbaum (1991). *Button Theory*: A Taxonomic Framework for Student-Teacher Interaction in Computer-Based Learning Environments, Northwestern University, The Institute for the Learning Sciences, Technical Report #12, Evanston, Illinois.


Overview
OVERVIEW
Related Topics
Boriiiaggg!
WHY
HOW
WHAT IS SPACE?
Space is generally considered to begin at the upper edge of the *atmosphere, about miles above the Earth's surface.
The solar system is part of space. It is composed of the Sun, which is a star, the 9 planets and their moons, asteroids , meteorites and comets.
The planets fall into 2 categories: the terrestrial planets and the gas giants.

Environment-dependent card 1

To demonstrate the use of "Boring" button
User clicks on "Boring" button.


Overview
OVERVIEW
Related Topics
HUH
WHY
HOW
Boring? OK then. You have 2 options (or rather 3) here. Please choose one.
See Story
Harder Level
None
The solar system is part of space. It is composed of the Sun, which is a star, the 9 planets and their moons, asteroids , meteorites and comets.
The planets fall into 2 categories: the terrestrial planets and the gas giants.

Environment-dependent card 2

He is presented with a choice of actions. He selects the "See Story" option.

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